(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
16. Januar 2003 (16.01.2003)

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(21) Internationales Aktenzeichen: PCT/EP02/07170

(22) Internationales Anmeldedatum: 28. Juni 2002 (28.06.2002)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
101 30 872.8 30. Juni 2001 (30.06.2001) DE

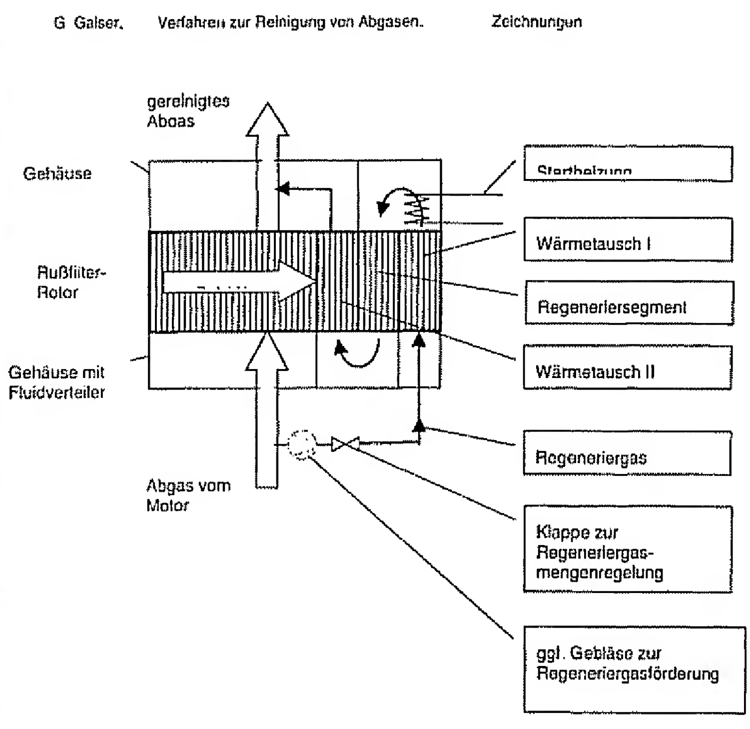
(71) Anmelder und
(72) Erfinder: **GAISER, Gerd** [DE/DE]; Langer Äcker 4, 72768 Reutlingen (DE).

(81) Bestimmungsstaaten *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU,

[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD FOR PURIFYING EXHAUST GASES

(54) Bezeichnung: VERFAHREN ZUR REINIGUNG VON ABGASEN



Dieselrußfilter-Rotor mit Teilstromregenerierung
Regeneriermedium Abgas (Teilstrom). Anordnung mit zwei Wärmetauschsegmenten

(57) Abstract: The invention relates to a method for purifying exhaust gases containing particulate impurities or nitrogen oxides. The exhaust gases are purified by a filtering matrix which is simultaneously regenerated. The filtering matrix is regenerated by a gas flow or air flow which is weak in relation to the exhaust gas flow. Preferably, the regeneration gas is preheated. The different functional regions are successively crossed. The inventive method can, for example, be carried out with rotating elements. The different functional areas are thus successively crossed by means of rotation.

(57) Zusammenfassung: Die Erfindung beschreibt ein Verfahren zur Reinigung von Abgasen, welche partikelförmige Verunreinigungen oder Stickoxide enthalten. Dabei werden Erfolgt die Reinigung der Abgase durch eine filternde Matrix gleichzeitig zur Regenerierung der filternden Matrix. Die Regenerierung der filternden Matrix erfolgt durch einen im Verhältnis zum Abgasstrom kleinen Gas- oder Luftstrom. Vorteilhaft wird das Regeneriergas vorgewärmt. Die unterschiedlichen Funktionsbereiche werden dabei nacheinander durchlaufen. Die apparatemässige Realisierung

[Fortsetzung auf der nächsten Seite]

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SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) **Bestimmungsstaaten** *(regional)*: ARIPO-Patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI-Patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Veröffentlicht:
— *mit internationalem Recherchenbericht*

(88) **Veröffentlichungsdatum des internationalen Recherchenberichts:** 17 April 2003

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

kann beispielsweise durch rotierende Elemente erfolgen. Dabei werden die unterschiedlichen Funktionsbereiche durch Rotation nacheinander durchlaufen.

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/EP 02/07170

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/02 B01D46/24 B01D46/26 B01D53/06 B01D53/56
B01D53/92 B01D53/94 F01N3/021 F01N3/08 B01D53/86

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 304 762 A (GRACE W R & CO) 1 March 1989 (1989-03-01) column 6, line 15 - line 22 column 8, line 47 -column 9, line 40; figure 8 column 10, line 26 - line 39; figure 12	1-29
X	DE 41 40 942 A (DAIMLER BENZ AG) 3 December 1992 (1992-12-03) column 2, line 13 - line 30; figures 1,2	1-29
X	EP 0 283 240 A (MATSUSHITA ELECTRIC IND CO LTD) 21 September 1988 (1988-09-21) column 4, line 14-42; figure 1	1-29
X	DE 36 09 848 A (DAIMLER BENZ AG) 1 October 1987 (1987-10-01) claims 1-6; figure	1-29

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 January 2003	23/01/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kanoldt, W

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/EP 02/07170

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 641 496 A (WADE WALLACE R) 10 February 1987 (1987-02-10) claim 1; figures 1-3 ---	1-29
X	EP 0 594 360 A (HITACHI SHIPBUILDING ENG CO) 27 April 1994 (1994-04-27) column 4, line 40 -column 8, line 5; figures 1-3 ---	1-29
X	EP 0 819 462 A (DAIMLER BENZ AG) 21 January 1998 (1998-01-21) column 8, line 20 -column 9, line 19; figure 3 ---	1-29
X	US 3 860 690 A (GIDASPOW DIMITRI) 14 January 1975 (1975-01-14) figure 2 ---	1-29
X	DATABASE WPI Section Ch, Week 199404 Derwent Publications Ltd., London, GB; Class E36, AN 1994-031028 XP002227207 -& JP 05 337333 A (HITACHI ZOSEN CORP), 21 December 1993 (1993-12-21) abstract; figure 2 ---	1-29
X	WO 85 03645 A (SRM SVENSKA ROTOR MASKINER AB) 29 August 1985 (1985-08-29) claims 1-15; figures 1-3 ---	1-29
X	US 4 701 189 A (OLIKER MICHAEL D) 20 October 1987 (1987-10-20) figures 1-15 ---	1-29
A	EP 0 718 476 A (TOYOTA MOTOR CO LTD) 26 June 1996 (1996-06-26) column 6, line 27 - line 44; figures 1-19 ---	1-29
A	US 3 897 539 A (FLEMING DONALD K) 29 July 1975 (1975-07-29) figures 2-4 ---	1-29
A	WO 98 56491 A (ENGELHARD CORP) 17 December 1998 (1998-12-17) figure 1 ----	1-29

INTERNATIONAL SEARCH REPORT

...mation on patent family members

Intern   al Application No
PCT/EP 02/07170

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			DE	69306909	T2	07-05-1997
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			EP	0819462	A2	21-01-1998
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Intern... al Application No
PCT/EP 02/07170

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 0718476	A	26-06-1996	JP	2943641	B2	30-08-1999
			JP	8177525	A	09-07-1996
			DE	69508546	D1	29-04-1999
			DE	69508546	T2	14-10-1999
			EP	0718476	A1	26-06-1996
			US	5697211	A	16-12-1997
US 3897539	A	29-07-1975	NONE			
WO 9856491	A	17-12-1998	AU	7471998	A	30-12-1998
			WO	9856491	A1	17-12-1998

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP 02/07170

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 7 B01D53/02 B01D46/24 B01D46/26 B01D53/06 B01D53/56
B01D53/92 B01D53/94 F01N3/021 F01N3/08 B01D53/86

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 7 B01D F01N

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

EPO-Internal, WPI Data, PAJ

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	EP 0 304 762 A (GRACE W R & CO) 1. März 1989 (1989-03-01) Spalte 6, Zeile 15 – Zeile 22 Spalte 8, Zeile 47 – Spalte 9, Zeile 40; Abbildung 8 Spalte 10, Zeile 26 – Zeile 39; Abbildung 12	1-29
X	DE 41 40 942 A (DAIMLER BENZ AG) 3. Dezember 1992 (1992-12-03) Spalte 2, Zeile 13 – Zeile 30; Abbildungen 1,2	1-29
X	EP 0 283 240 A (MATSUSHITA ELECTRIC IND CO LTD) 21. September 1988 (1988-09-21) Spalte 4, Zeile 14-42; Abbildung 1	1-29

-/--

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

° Besondere Kategorien von angegebenen Veröffentlichungen :

"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist

"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist

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"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
14. Januar 2003	23/01/2003

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kanoldt, W

Formblatt PCT/ISA/210 (Blatt 2) (Juli 1992)

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	DE 36 09 848 A (DAIMLER BENZ AG) 1. Oktober 1987 (1987-10-01) Ansprüche 1-6; Abbildung ---	1-29
X	US 4 641 496 A (WADE WALLACE R) 10. Februar 1987 (1987-02-10) Anspruch 1; Abbildungen 1-3 ---	1-29
X	EP 0 594 360 A (HITACHI SHIPBUILDING ENG CO) 27. April 1994 (1994-04-27) Spalte 4, Zeile 40 -Spalte 8, Zeile 5; Abbildungen 1-3 ---	1-29
X	EP 0 819 462 A (DAIMLER BENZ AG) 21. Januar 1998 (1998-01-21) Spalte 8, Zeile 20 -Spalte 9, Zeile 19; Abbildung 3 ---	1-29
X	US 3 860 690 A (GIDASPOW DIMITRI) 14. Januar 1975 (1975-01-14) Abbildung 2 ---	1-29
X	DATABASE WPI Section Ch, Week 199404 Derwent Publications Ltd., London, GB; Class E36, AN 1994-031028 XP002227207 -& JP 05 337333 A (HITACHI ZOSEN CORP), 21. Dezember 1993 (1993-12-21) Zusammenfassung; Abbildung 2 ---	1-29
X	WO 85 03645 A (SRM SVENSKA ROTOR MASKINER AB) 29. August 1985 (1985-08-29) Ansprüche 1-15; Abbildungen 1-3 ---	1-29
X	US 4 701 189 A (OLIKER MICHAEL D) 20. Oktober 1987 (1987-10-20) Abbildungen 1-15 ---	1-29
A	EP 0 718 476 A (TOYOTA MOTOR CO LTD) 26. Juni 1996 (1996-06-26) Spalte 6, Zeile 27 - Zeile 44; Abbildungen 1-19 ---	1-29
A	US 3 897 539 A (FLEMING DONALD K) 29. Juli 1975 (1975-07-29) Abbildungen 2-4 ---	1-29
A	WO 98 56491 A (ENGELHARD CORP) 17. Dezember 1998 (1998-12-17) Abbildung 1 -----	1-29

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichur... ...e zur selben Patentfamilie gehören

Intern...ales Aktenzeichen
PCT/EP 02/07170

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie			Datum der Veröffentlichung
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			JP	5032562	B	17-05-1993
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			JP	1053010	A	01-03-1989
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			JP	5051764	B	03-08-1993
			AU	597479	B2	31-05-1990
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			CA	1308361	A1	06-10-1992
			DE	3874924	D1	05-11-1992
			DE	3874924	T2	01-04-1993
			EP	0283240	A2	21-09-1988
			US	4840028	A	20-06-1989
DE 3609848	A	01-10-1987	DE	3609848	A1	01-10-1987
US 4641496	A	10-02-1987	CA	1244356	A1	08-11-1988
			DE	3569404	D1	18-05-1989
			EP	0188075	A1	23-07-1986
			JP	61145312	A	03-07-1986
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			JP	6178913	A	28-06-1994
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			DE	69306909	D1	06-02-1997
			DE	69306909	T2	07-05-1997
			DK	594360	T3	16-06-1997
			EP	0594360	A1	27-04-1994
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EP 0819462	A	21-01-1998	DE	19628796	C1	23-10-1997
			DE	59703493	D1	13-06-2001
			EP	0819462	A2	21-01-1998
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US 3860690	A	14-01-1975	KEINE			
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Formblatt PCT/ISA/210 (Anhang Patentfamilie)(Juli 1992)

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichun.. ... zur selben Patentfamilie gehören

Interna... es Aktenzeichen
PCT/EP 02/07170

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Formblatt PCT/ISA/210 (Anhang Patentfamilie)(Juli 1992)

(12) INTERNATIONAL APPLICATION PUBLISHED PURSUANT TO THE PATENT COOPERATION TREATY

(19) World Organization for Intellectual Property
International Office

(10) International publication number:
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(43) International publication date:
January 16, 2003 (01/16/2003)

PCT

(51) International patent classification[7]: **B01D 53/02**

(21) International filing number: PCT/EP02/07170

(22) International filing date: June 28, 2002 (06/28/2002)

(25) Language of submission: German

(26) Language of publication: German

(30) Priority data:
101 30 872.8 June 30, 2001 (06/30/2001) DE

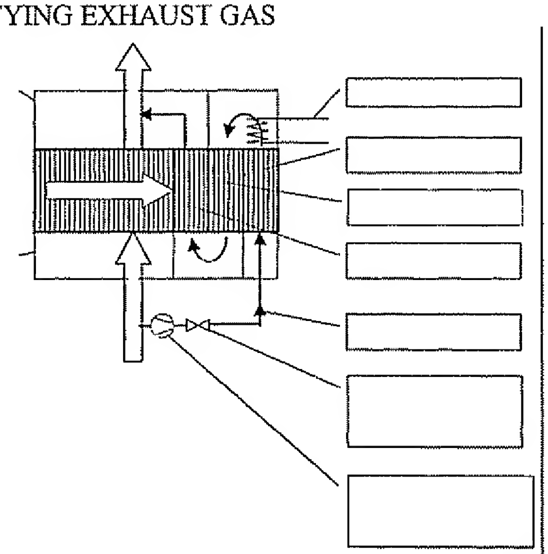
(71) Applicant and
(72) Inventor: GAISER, Gerd [DE/DE]; Langer Äcker 4, 72768 Reutlingen (DE)

(81) Designated states (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated states *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW). Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR). OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, MI, MR, NE, SN, TD, TG).

[continuation on the next page]

(54) Title: METHOD FOR PURIFYING EXHAUST GAS



Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with two heat exchange segments

(57) Abstract: The invention relates to a method for purifying exhaust gases containing particulate impurities or nitrogen oxides. The exhaust gases are purified by a filtering matrix, which is simultaneously regenerated. The filtering matrix is regenerated by a gas flow or air flow which is weak in relation to the exhaust gas flow. Preferably, the regenerating gas is preheated. The different functional regions are successively crossed. The inventive method can be carried out, for example, with rotating elements. Thus, the different functional areas are crossed successively by means of rotation.

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Method for Purifying Exhaust Gases

Description

Background Art:

Removal of Soot Particles from the Exhaust Gas:

The purification of the exhaust gas stream from diesel exhaust gases presents a real problem in light of the limit values, which are becoming more and more stringent. In addition to the removal of nitrogen oxides as well as small amounts of CO and hydrocarbons, the removal of soot particles is predominantly gaining in importance.

The exhaust gas in diesel engines is characterized by a strong exhaust gas flow (based on the output) and a low exhaust gas temperature. The strong exhaust gas flow (based on the output) results from the large displacement of diesel engines (based on the output) in connection with a very high compression and a high amount of excess air during combustion.

A middle class truck engine of 6.8 liters displacement and an output of 280 HP results in an exhaust gas flow of approximately 1,000 Nm^3/h. Even a middle class passenger car with an output of about 100 HP under full load results in an exhaust gas flow exceeding 300 Nm^3/h.

As a consequence, the exhaust gas system exhibits very high flow rates. For example, the Otto engine in passenger cars already has a catalyst monolith that in the full load range reaches rates of up to 40 m/sec. For diesel engines, these values are in the same order of magnitude. In light of the high rates, the exhaust gas system must be designed for as low a pressure loss as possible.

There exist a number of different designs for removing soot particles. However, to date none of these designs has gained acceptance for large scale production.
In general, the practice is to use particulate filters that have predominantly the shape of parallel square channels, in which the exhaust gas flows through the porous ceramic wall so that the particles settle out on the wall. At certain time intervals, these particulate filters have to be regenerated. Therefore, the particulate filter is heated to a high temperature so that the deposited soot particles burn up and, thus, make the particulate filter available for filtering again.

Other designs provide metal filters made of wire mesh, metal fleece, sintered metal fleece or sintered metal shapes. Even these particulate filters are regenerated at a high temperature.

The problem with the filter lies in the regeneration process. First of all, this process requires temperatures that are significantly higher than the usually prevailing exhaust gas temperature. Therefore, the past designs have proposed that the regeneration be initiated by igniting a burner. However, these designs do not usually allow regeneration while the vehicle is travelling. First of all, the strong exhaust gas flow would make the necessary power input for the burner too large. The second reason lies in the fact that the burning of the soot particles releases a large amount of heat. If the combustion is uncontrolled, the result may be very high temperatures, which may result in the destruction of the material. Therefore, the regeneration, proposed by these designs, has to take place when the vehicle is stationary. In this case, the combustion may be influenced by controlling the amount of air that is added; and, thus, the temperature can be limited. However, the result of this procedure is the serious drawback that the regeneration can only be conducted in the stationary state.

In the interim, other designs have proposed conducting the regeneration while the vehicle is travelling. In this case, the exhaust gas is heated to the temperature required for regeneration by a burner or by an electric heating system. However, owing to the large amounts of exhaust gas that is present, this solution requires a large additional input of energy, which in turn is tied to a significantly higher consumption of fuel.

In another design, investigated by companies, an oxidation catalytic converter, which is upstream of the particulate filter, converts the hydrocarbons contained in the exhaust gas. Thereafter, the particulate is filtered. For the purpose of regeneration, a specific hydrocarbon-rich exhaust gas (enriched mixture) is now produced by the engine control system at certain time intervals. When this exhaust gas is oxidized in the oxidation catalytic converter, the higher concentrations lead to high exhaust gas temperatures. In this case, a suitable control of the engine will raise the exhaust gas temperature so high that the igniting temperature of the soot particulate in the downstream particulate filter is reached. In this way, the regeneration of the particulate filter is initiated. The drawback with this process is that, prior to the start of the regeneration process, the temperature of the particulate filter depends on the respective current load condition in the engine and may, therefore, depend almost randomly on the respective driving mode. Another drawback is that after igniting the regeneration process, the reaction runs automatically owing to the reaction heat that is released upon burning the particulate. Therefore, the temperature in the particulate filter rises even higher. Since this regeneration runs while the engine is operating, the amount of exhaust gas that is present during this operation is undefined and depends on the momentary operating mode. Therefore, the temperature in the particulate filter is subject to random influences and, thus, can be controlled only with difficulty.

Another design proposes connecting an oxidation catalytic converter upstream of the particulate filter. This catalytic converter oxidizes the NO (nitrogen monoxide), which is also contained in the exhaust gas, to NO_2 (nitrogen dioxide). This NO_2 acts as the oxidizing agent in the downstream particulate filter, so that the oxidation of the collected particulate is supposed to run at lower temperatures. However, in practice, even in this system, the exhaust gas temperatures are inadequate for regenerating the filter, so that, even in this case, the temperature of the exhaust gas has to be raised by an additional input of energy.

Another problem is the uniformity with which the particulate burns on the particulate filter. This burning is determined by the uniformity of the particulate layer on the particulate filter and on the uniformity of the throughflow of the particulate filter. A typical non-uniform layer of particulate on the surface of the particulate filter leads to a non-uniform throughflow, to a non-uniform burning of the soot, and, thus, to non-uniform temperatures on the particulate filter. If, at the same time, the particulate is burned with an uncontrolled amount of exhaust gas, the result may be local temperature spikes that may destroy the particulate filter.

Another patent (Ceryx company) proposes conveying the exhaust gas stream through an additional heat exchanger in which the heat from the cleaned exhaust gas is supposed to be transferred to the uncleaned exhaust gas. This procedure also provides an additional input of energy by means of the addition of fuel. The additional input of energy is decreased only slightly by the heat exchanger. The drawback with this design is that the exhaust gas stream has to flow through the heat exchanger twice. This feature is associated with a sizeable additional pressure loss, which in the case of strong exhaust gas flows. leads to a dramatic loss in power. In the case of this design, the transfer of heat requires a driving temperature gradient, which is generated only to some extent by the liberated heat of the reaction. The difference between the heat, which is carried away by means of the exhaust gas stream, and the reaction heat, which is released by the pollutants in said exhaust gas, has to be supplied by the additional combustion of fuel. The better the return of heat, the lower the additional input of heat is. However, the reduction in the driving temperature difference - for example, by means of an area, which transfers heat for a prolonged period of time, or by means of installations having a higher heat transfer - leads automatically to a higher pressure loss and, thus, to an additional engine output loss.

Exhaust gas from modern engines, which at this time have already reached the EURO - 3 limits, contains just small amounts of particulate, so that the released reaction heat is also low. The analysis for a modern truck engine shows that an adiabatic temperature increase of, at most, just a few degrees can be achieved with the resultant soot particles. Even if additional pollutants, like hydrocarbons and CO (their content is low owing to the large amount of excess air in diesel engines), are taken into consideration, one can assume an adiabatic temperature increase of approximately 10 degrees.

In summary, it is clear that in the case of strong exhaust gas flows precisely, the additional heat input can become sizeable. Another drawback of this process is that even the heat transfer is defined by the amount of exhaust gas. This amount, in turn, just as in the case of the exhaust gas temperature, is defined by the respective load condition of the engine and is, thus, subject to random fluctuations, which cannot be determined in advance and are induced by the driving mode.

Removal of Nitrogen Oxides from the Exhaust Gas:

As stated above, the combustion processes in the diesel engine are characterized by a large amount of excess air. As a result, there are certainly fewer pollutants from the incomplete combustion (for example, CO, hydrocarbons), but at the same time the formation of nitrogen oxide is significantly more noticeable.

Therefore, the removal of nitrogen oxides presents a problem that has not been satisfactorily yet solved with respect to diesel engines. The problem arises primarily from the large amount of excess oxygen in the exhaust gas. In contrast to the three way catalytic converter in Otto engines, in the oxygen-rich atmosphere of diesel exhaust gases, the nitrogen oxides cannot be easily reduced to nitrogen.

A similar problem will arise in Otto engines featuring the lean burn engines that can be expected in the future and that also operate with a higher amount of excess air during engine combustion.

To date, there exist two methods for removing nitrogen oxides from the diesel exhaust gas, and they are currently still in the pilot test phase. The one method constitutes selective catalytic reduction with the use of reductants; and the other method uses so-called storage catalysts.

The process of selective catalytic reduction (SCR) is known from the removal of nitrogen oxide from flue gases from industrial furnace plants. For these applications, ammonia is used as the reductant, with the aid of which the nitrogen oxides are reduced on a catalyst. Currently the transfer of this process to diesel engines, in particular truck engines, is still in the pilot test phase. In the mobile applications of diesel engines, a urea solution is usually used as the reductant. In addition, there exist other methods using ammonia-releasing substances (for example, ammonium-carbamate). The drawback with this method is that an additional reductant is needed. Since it is carried along in a tank in the vehicle, it has to be refilled at regular intervals. Additional problems lie in the requirement that the reductant must be added uniformly. A non-uniform loading results in a so-called slip, which emits unconsumed reductant. For this reason, another method is currently under development, in particular for application in passenger cars.

This second method uses so-called storage catalysts, which are capable of intermittently bonding nitrogen oxides by sorption. Thus, during normal running engine operation, the nitrogen oxides in oxygen-rich exhaust gas are adsorbed from the exhaust gas and are chemically bonded to the storage catalyst. After a certain period of time, regeneration must occur. To this end, the engine control generates a low-oxygen exhaust gas for a short period of time. As a result of the low-oxygen exhaust gas and the hydrocarbons contained therein, the nitrogen oxides, which are bonded to the storage catalyst, are reduced. Upon completion of this short regeneration phase, the motor control unit adjusts again to the normal running operation with oxygen-rich exhaust gas. The working temperature of the method is approximately 350 °C

and, thus, in the magnitude of the diesel exhaust gas temperature. The advantage of this method is that no additional reductant has to be carried along in the vehicle. However, this advantage is counteracted by a number of drawbacks. First of all, the mandatory periodic regeneration with the mandatory enrichment of the mixture is a problem, because it leads, in particular, to an intermittent behavior of the engine and the exhaust gas purification. During the short regenerating cycle, all of the cylinders, emitting into a catalytic converter, have to be operated at a poor operating point. The resulting change in the output and torque of the engine has to be compensated by additional measures of the engine control unit in order to provide the vehicle with continuous power. Other drawbacks with an operation that uses an enriched mixture lies in the short-term higher emission of hydrocarbons and, thus, the short-term higher consumption as well as a possible short-term sudden jump in emission.

In the English language literature, these storage catalysts are also referred to as NOx absorbers or NOx traps. The reactions that run at the storage catalyst during loading and regeneration can also be derived from the prior art.

Object of the Invention:

The object of the invention is to provide a system for continuous particulate filtering and for regeneration during exhaust gas purification. The regeneration operation shall run largely autothermally, so that additional heating can be largely avoided. In addition, the method shall be insensitive to load cycles in the engine, which lead, as well-known, to wide variations in the amount of exhaust gas, pollutant concentration and exhaust gas temperature. Another embodiment of the invention shall integrate the removal of nitrogen oxide from the exhaust gases.

Inventive Solution:

The cause for the problems associated with local temperature spikes during regeneration of particulate filters lies, first of all, in the relatively long regeneration intervals, which can lead to relatively high local particulate concentrations. Continuous oxidation of the soot particles could eliminate this problem, but at the cost of a continuously high demand for additional energy. The reason for this high demand is that the heat is carried away by the exhaust gas stream.

Both problems can be avoided by means of the invention as follows. In a first zone of a system, which is suitable for the inventive method and which is provided with a suitable particulate-filtering medium, which shall be specified below, the soot particles are removed from the exhaust gas stream and deposited on the filtering medium. In a second zone of the system, the regeneration of the filtering medium takes place. The crucial factor is that the regeneration takes place only with a weaker substream of air or exhaust gas. The use of a substream makes it possible to achieve the following advantages. First of all, less heat is carried away merely because only a weaker substream at a higher temperature is carried away. Secondly, the amount of the substream can be controlled. Therefore, the burning of the particulate can be influenced by adjusting the amount of oxygen that is delivered so that the temperature does not get too high. This operation in the second zone of the system takes place independently of the exhaust gas purification that runs simultaneously in the first zone of the system. Furthermore, it may be practical in a third zone of the system to preheat the regenerating gas by means of a filtering medium that is heated during the regeneration. Exhaust gas purification, regenerating cycle and heat recovery are conducted cyclically in the individual zones of the system.

The individual zones of the system can be divided into single devices or partial devices. In this case the respective exhaust gas stream, regenerating gas stream and hot gas stream can be guided in temporal alternation through the partial devices. It is especially advantageous to integrate the individual zones into

one device. In this case, an especially suitable possibility may be the use of a rotor. The rotor may contain a particulate-filtering medium or may consist of such, for example, a particulate filter (see below).

By means of a rotational movement of the rotor in relation to the exhaust gas feed and discharge the individual process steps - exhaust gas purification, regeneration and heat exchange - are carried out in succession. It may prove to be more advantageous for the construction of the device if the system is designed stationary, whereas the exhaust gas feed and the exhaust gas discharge are designed as rotating exhaust gas distributors.

In another advantageous embodiment, the individual zones of the system may be designed as separate devices to which the exhaust gas is delivered in certain cycles. The change-over from exhaust gas feed to exhaust gas discharge in the individual zones may also take place by means of cyclically enabled flaps or valves. In this case, the flow into the individual zones or partial devices may alternate cyclically. This cyclical alternation is simpler to explain with the rotor as an example.

In this case, the term "rotor", as used below, is defined so as to include a configuration in which the particulate-filtering medium is housed in a stationary arrangement, whereas the fluid infeeds are rotated. Moreover, the following description of the function can also be transferred to the design that exhibits individual separate devices. For the sake of simplicity, the rotating particulate-filtering medium with stationary fluid infeeds shall be described below as an example.

In this case, the individual zones are alternated by rotating the rotor as follows. A number of different fluid streams flow into the individual zones or segments of the rotor by means of suitable flow infeeds.

In the first zone, the exhaust gas flows through the particulate-filtering medium of the rotor and is cleaned. This process step takes place independently of the temperature, the composition and the amount of the exhaust gas flow. When the rotor rotates, the particulate-loaded, particulate-filtering medium moves into the regenerating zone. In this zone, the loaded particulate-filtering medium is regenerated with a weaker substream of the exhaust gas. In place of a substream of the exhaust gas, air can also be used. The burning of the deposited particulate can be controlled by the amount of air or exhaust gas flow (and the amount of oxygen delivered thereby). Hence, excessive temperatures can be avoided. The regenerating gas and the particulate filter are heated by means of the reaction heat that is released while the particulate is burning. In the sense of a small heat loss, this heat can be recovered in other zones of the rotor and used for preheating the regenerating gas. If desired, heat-transferring zones can also be configured upstream or downstream of the rotor (see below).

Owing to the use of a weak substream for regeneration. there are significantly smaller heat losses; an autothermal operation is possible. When a substream of the exhaust gas is used, it can be branched off from the exhaust gas flow by means of a controlled flap. Thus, an extensive independence from the load cycle profile of the engine can be achieved.

Regenerating Gas Stream

A substream of the exhaust gas can be used in order to regenerate the loaded particulate-filtering medium. This substream can be branched off from the exhaust gas stream by means of a controlled flap.

As an alternative, clean air can also be used for regeneration. Which of the two options is more practical depends on the flow pattern (to be discussed below).

Amount of Regenerating Gas:

The amount of regenerating gas or the amount of regenerating air is derived from the required amount of oxygen that is necessary for burning all of the particulate that has settled out. In order to avoid excessive temperatures, the amount of regenerating gas or the amount of regenerating air can be controlled, in such a manner, that a certain temperature is not exceeded during the burning process. If the speed of the rotor and, thus, the regenerating cycles are suitably selected, this restriction is not necessary. In so far as the oxygen curb leads to an undesired formation of CO, it can be converted (if desired, after a further addition of air) in a downstream catalyst. A catalyst can also be disposed by choice, at least in subareas of the particulate-filtering medium. Even areas of the particulate-filtering medium may be equipped - for example, coated - with catalysts. In addition, the amount of regenerating gas has to be adjusted to the duration of the regenerating cycle. In the case of the rotor, the duration of the regenerating cycle may be easily changed by varying the speed. Furthermore, in the case of the rotor, the respective cleaning and regeneration periods can be defined by dividing the area into individual zones.

Oxidation Catalyst:

In order to accelerate the oxidation reaction, a catalyst can be disposed at least in the subareas of the particulate-filtering medium. Even areas of the particulate-filtering medium can be coated with catalysts. If an oxidation catalyst - for example, a precious metal-containing catalyst - is used for the coating, then any CO that has formed can be oxidized on said catalyst. Similarly the oxidation of the soot particles that have settled out can be accelerated by a catalyst.

Furthermore, this method may be combined with storage catalysts for removing nitrogen oxides from the exhaust gas. This possibility shall be described below.

Regenerating Intervals:

The regenerating intervals can be adapted to the engine load profile and the resulting amount of accumulated particulate. In the case of the rotor, this adaptation can be easily carried out by means of the speed. If clocked individual devices are used, this adaptation can be carried out by means of the clock time.

Division of the Rotor Segments

The functional areas of the rotor are established by the configuration of the fluid feed and discharge lines. Thus, the segmentation for the areas exhaust gas cleaning, regeneration and heat exchange can also be predefined. Within the scope of this invention, the largest segment of the rotor shall be available for cleaning the exhaust gas stream. A smaller segment of the rotor shall be used for regenerating the particulate-filtering medium. The heat exchange can take place in an additional segment, which is also smaller.

The required ratio of the exhaust gas segment to the regenerating segment, in terms of size, is determined, on the one hand, by the particulate loading of the engine exhaust gas and, on the other hand, by the specified maximum particulate loading of the filter material as well as by the specified duration of the regeneration.

Design / Construction

An especially suitable design possibility may consist of the use of a rotor. The rotor may contain a particulate-filtering medium or consist of such - for example, a particulate filter (see below). Owing to the individual fluid feed and discharge lines, the rotor exhibits individual functional areas ("rotor" design).

As an alternative, it is also possible to use a design, wherein the particulate-filtering medium is mounted stationarily, whereas the fluid feed and discharge lines are rotated ("stator" design). The design with a stationary particulate filter and rotating fluid distributors may be more practical with sensitive ceramic filter mediums. In this case, it may be desirable not to mount the rotating fluid distributors directly on the filter material. Rather a transition region can be arranged at that point. Then the seal may be uncoupled from the ceramic matrix. In this case, this transition region must also exhibit a division into segments in order to suppress commingling between the individual segments.

Instead of the rotor or stator design, the system may also consist of individual partial devices, through which the respective fluid streams alternatingly flow. In this case, the change-over of the fluid streams between the individual partial devices takes place by means of suitable flaps or valves.

Method of Operation of Rotor / Stator

In the rotor design and in the stator design, the rotation may be either continuous, or it may be a clocked rotational movement, in which the rotating unit continues to rotate about a certain segment.

Type of Particulate-Filtering Material:

Various materials and various designs can be used as the particulate-filtering matrix in the device.

First of all, it may be a ceramic honeycomb monolith particulate filter, wherein the individual channels are closed alternatingly at the inlet or at the outlet. (So-called wall flow filter) As an alternative, the device may have a ceramic fiber filter, a metal fiber filter or a metal fleece filter. Furthermore, sintered metal filters or sintered ceramic filters may be used.

The metal designs offer the advantage of higher stability to thermal stresses and a higher stability to temperature variations.

Shape of the Particulate-Filtering Material:

The particulate-filtering materials may exhibit a honeycomb structure, as is known from existing particulate filters. Owing to the parallel channels, this shape offers the advantage that the flow is guided in the flow direction without any cross components. Thus, a cross commingling between the individual regions can be avoided without any additional measures.

As an alternative, the particulate-filtering material may be constructed in the form of a fleece material or fiber mats. In this case the rotor cross section should be divided into individual segments, between which a cross commingling can be avoided, in order to avoid a cross flow.

A configuration of the filter material, in the form of parallel walls, is also possible. In order to form segments, these walls may also be constructed in a star configuration so that the results are segments.

In another type of construction, a continuous particulate-filtering material is folded in a zig-zag configuration, as known from prior art air filters. Thus, if the material is suitably folded, the results are also the formation of segments.

Type of Rotor / Stator:

The simplest type of rotor or stator may consist of a cylindrical monolith. This construction offers, for example, advantages if ceramic honeycomb monoliths are used.

It is also possible to configure the rotor or the stator in the form of a hollow cylinder. This design may be practical with the use of particulate-filtering elements that are folded in a zig-zag configuration.

In the case of a cylindrical design, it is desirable that the individual fluid streams flow in the axial direction. In the case of the hollow cylinder, the flow may be guided in both the axial and the radial direction.

Upstream or Downstream Heat Exchanger Zones:

In another design, heat-exchanging zones may be configured either upstream or downstream of the rotor. These zones may be designed, for example, as heat exchangers. Thus, an additional improvement in the heat exchange can be achieved.

Other Applications:

In addition to the use for exhaust gas purification in diesel engines, this invention can also be used with other engine designs (for example, Otto engines with direct injection), which emit substances or particles that collect on a filter that has to be subsequently cleaned in a regeneration step.

Other applications may also arise in conjunction with the purification of stationary waste air, if, for example, aerosol-containing waste air streams or particle-laden waste air streams have to be purified.

Combination of a Method for Removing Nitrogen Oxide and Storage Catalysts

The inventive method can be combined in an especially advantageous manner with a method for the removal of nitrogen oxide and storage catalysts.

To this end, the particulate-filtering medium may be equipped, preferably coated, with a storage catalyst. The exhaust gas, in normal engine running operation, is always cleaned in a first zone of a system, which is suitable for the inventive method. In so doing, the nitrogen oxides are bonded to the storage catalyst. The storage catalyst is regenerated in a second zone of the system. The crucial factor is that the regeneration takes place only with a weaker substream of the exhaust gas. The use of a substream offers the following advantages. First of all, the substream can be controlled independently of the respective load condition of the engine. Thus, the regeneration can always take place with a constant stream or selectively with an adjusted substream. Another advantage lies in the fact that only a weak substream with a low-oxygen and, if desired, hydrocarbon-containing exhaust gas has to be generated.

As a result of this method, the crucial advantages are achieved that, for example, the engine is always running in a normal operating mode; and it is not necessary to switch to the regeneration operation with an enriched mixture.

In an especially advantageous design of the method, the soot particles settle out and attach continuously to the filtering medium in a first zone of the system; and simultaneously the nitrogen oxides are bonded to the storage catalyst. Thus, the exhaust gas is cleaned simultaneously of the soot particles and the nitrogen oxides. In addition, the use of a suitable, oxidation-accelerating catalyst makes it also possible to remove

hydrocarbons and carbon monoxide from the exhaust gas in the same zone. Then the particulate-filtering medium and the storage catalyst are continuously regenerated in other zones of the system.

In the regenerating segment, a low-oxygen and, if desired, carbon monoxide-containing gas may be generated during the regeneration of the particulate-filtering medium by controlling the substream. Then, in a regenerating segment, the storage catalyst can be regenerated with such a low-oxygen and, if desired, carbon monoxide-containing gas.

In this case, the term storage catalyst is defined as a composition, which is capable of bonding nitrogen oxides from the oxygen-containing exhaust gas and can be regenerated again under low-oxygen and, if desired, oxidative conditions (for example BaO). Therefore, typical storage catalysts comprise three active components: an oxidation catalyst (for example, platinum), an adsorbent (for example, barium oxide) and a reducing catalyst (for example, rhodium). In this case, the adsorbent may contain elements from the groups of alkaline earths, alkali metals or rare earths.

As described above for the pure particulate filter method, the individual zones of the system may be divided into individual devices or partial devices. In this case, the respective exhaust gas stream, regenerating gas stream and hot gas stream can be guided in temporal alternation through the partial devices. It is especially advantageous to integrate the individual zones into one device. In this case, an especially suitable possibility may be the use of a rotor.

The term "rotor" is used below in a manner analogous to the pure particulate filtering method. In this case, the term "rotor" is defined to include a configuration, in which the particulate-filtering medium is housed in a stationary arrangement, whereas the fluid infeeds are rotated. Moreover, the following description of the function can also be transferred to the design exhibiting individual separate devices. For the sake of simplicity the rotating particulate-filtering medium with stationary fluid infeeds shall be described below as an example.

In this arrangement, the simultaneous removal of soot by means of the particulate-filtering material and the removal of the nitrogen oxides by means of the storage catalyst take place in the largest zone of the rotor. As the rotor rotates, the zones, loaded with soot and nitrogen oxide, move into the regenerating zone, where soot particles that have settled out are oxidized in the above described manner in a first step with the use of a weak regenerating gas stream. Owing to the control of the amount of regenerating gas, the following effects can be achieved. First of all, the temperature can be limited. Secondly, a low-oxygen gas can be produced with a small amount of regenerating gas. Third, the amount of regenerating gas can be reduced to such an extent that the oxygen it contains is totally consumed. In addition, a carbon monoxide-containing gas is produced. Such a carbon monoxide-containing gas can be used in an especially advantageous manner for regenerating the storage catalyst. For control purposes, the oxygen content, which is measured by means of a lambda probe, can be used.

The storage catalyst can be regenerated with the gas that is produced by the oxidation of the particles. Thus, the particulate filter and the storage catalyst can also be regenerated in sequential segments. However, it is especially advantageous to regenerate both in the same segment.

In principle, additional fuel can also be added to the regenerating gas, in order to regenerate the storage catalysts. However, regeneration with carbon monoxide-containing gas has the advantage that no additional fuel is necessary.

Regenerating Gas Stream:

A substream of the exhaust gas can be used in order to regenerate the loaded particulate-filtering medium. This substream can be branched off from the exhaust gas stream by means of a controlled flap. Thus, an extensive independence from the engine load cycle profile can be achieved. In addition, owing to this independent gas substream, the conditions for regeneration are optimized.

In combination with the particulate filter with substream regeneration, clean air can also be used for regeneration. Which of the two options is more practical depends on the flow pattern (to be discussed below).

Amount of Regenerating Gas:

The amount of regenerating gas or the amount of regenerating air can be controlled by a flap independently of the respective load condition of the engine.

In addition, the amount of regenerating gas has to be adjusted to the duration of the regenerating cycle. In the case of the rotor, the duration of the regenerating cycle can be easily changed by varying the speed.

Regenerating Intervals:

The regenerating intervals can be adapted to the engine load profile and the resulting amount of accumulated nitrogen oxides. In the case of the rotor, this adaptation can be easily carried out by means of the speed. If clocked individual devices are used, this adaptation can be carried out by means of the clock time.

Division of the Rotor Segments

The functional areas of the rotor are established by the configuration of the fluid feed and discharge lines. Thus, the segmentation for the areas exhaust gas cleaning and regeneration can also be predefined. Within the scope of this invention, the largest segment of the rotor shall be available for cleaning the exhaust gas stream. A smaller segment of the rotor shall be used for regenerating the storage catalyst. When this method is combined with the particulate filter, the heat exchange can also take place in another segment that is also smaller.

The required ratio of the exhaust gas segment to the regenerating segment in terms of size is determined, on the one hand, by the NOx concentration of the engine exhaust gas and, on the other hand, by the specified maximum loading of the storage catalyst as well as by the specified duration of the regeneration.

Design / Construction

An especially suitable design possibility may consist of the use of a rotor. The rotor may be coated with storage catalysts at least in areas or may consist totally of this storage catalyst. Owing to the individual fluid feed and discharge lines, the rotor exhibits individual functional areas ("rotor" design).

As an alternative, it is also possible to use a design wherein the storage catalyst is mounted stationarily, whereas the fluid feed and discharge lines are rotated ("stator" design). The design with a stationary storage catalyst and rotating fluid distributors may be more practical with sensitive ceramic carrier mediums.

Instead of the rotor or stator design, the system may also consist of individual partial devices, through which the respective fluid streams flow alternatingly. In this case, the change-over of the fluid streams between the individual partial devices takes place by means of suitable flaps or valves.

In all of the configurations it may be desirable to coat a subarea of the carrier matrix with storage catalysts, whereas other uncoated areas are available for the heat exchange. Thus, it is possible, for example, to set an optimal operating temperature range for the storage catalyst.

In addition, it may also be advantageous to set a high temperature profile of approximately 700 °C, through the configuration and size of the heat-exchanging areas in the segments and by the configuration of the aforementioned heat-exchanging segments. At this temperature, sulfur poisoning of the storage catalyst can be decreased.

Type of Carrier Matrix for the Storage Catalyst:

Various materials and various designs can be used as the carrier matrix in the device.

In principle, all carrier materials that are also used in conventional storage catalysts may be used. The same applies to the type of storage catalysts that are used. In the current case, all materials that are also used in conventional storage catalysts may also be used. Thus, the ceramic matrix may be, for example, a ceramic honeycomb monolith, which serves as the carrier matrix for the storage catalyst.

When the method with the particulate filter is combined with substream regeneration, the carrier for the storage catalyst may also be a ceramic honeycomb monolith particulate filter, wherein the individual channels are closed alternatingly at the inlet or at the outlet.

As an alternative, the device may also have a ceramic fiber filter or a metal fiber filter and be coated with storage catalysts.

Furthermore, sintered metal filters or sintered ceramic filters may be used that may also exhibit, in certain areas, a coating with storage catalysts.

It is also possible to arrange the particulate-filtering matrix and the storage catalyst in succession one after the other.

It is also possible to mount the storage catalyst on an additional carrier in channels of the particulate-filtering matrix. In this case, it is especially advantageous if on the side facing away from the engine, the channels of the particulate-filter are equipped with the storage catalyst on an additional carrier.

Transfer of the Oxidative Rotor Substream Regeneration to Other Methods:

The invention can also be transferred to other methods that need periodic regeneration. It may be, for example, the combination of adsorptive waste air purification and subsequent oxidative regeneration of the adsorbent. In this case, the adsorbed components can be regenerated directly on the adsorbent. In this combination of methods, the use of the rotor with substream regeneration, also offers the decisive advantage of a continuous operation.

Examples of Circuit Variants

The following descriptions disclose a number of different examples of the circuit variants. The illustrated variants are only examples and do not show all of the above described configurations.

In the following figures, a rotor design is used as an example to show the types of circuits. Identical circuits are also possible for stator designs or for separate partial devices with a change-over by means of flaps or valves (clocked devices). In all of the figures, the rotor with the segments was shown, as depicted in Figure 8, by means of a substitution diagram.

Figure 1 depicts the exemplary configuration of a rotor, which shall be used as an example to explain the method for cleaning the exhaust gases in the following designs. The rotor (1) comprises a matrix (2). This matrix can be made of a particulate-filtering material or at least contain such a particulate-filtering material in certain areas. Upstream of the rotor is an inflow zone (3) and downstream of the rotor is an outflow zone (4). In the inflow and outflow zones, the throughflow of the rotor is divided into multiple segments (5). The rotor itself may exhibit a continuously homogeneous construction. A number of different gas streams may flow through the individual segments. By rotating the rotor (1) the rotor matrix runs in succession one after the other through the various segments. At the same time, various streams may flow through said rotor, as to be described below.

In order to simplify the presentation, a substitution diagram shall be used in the following. This substitution diagram is shown in Figure 2. In this case, the rotational movement of the rotor is depicted as a linear movement. The throughflow of the rotor matrix into the individual segments shall be illustrated by the individual zones (6).

Figure 3 depicts an exemplary design of a stator design. This stator contains a stationary matrix (7). Upstream of the matrix is a rotating inflow zone (8); and downstream of the matrix is a rotating outflow zone (9). The inflow and the outflow zones may be divided into several segments (10). If the inflow zone and the outflow zone are rotated synchronously, the stationary matrix can be loaded with the various gas streams in temporal and local alternation. The stator design shall also be explained by means of a substitution diagram. Figure 4 is a substitution diagram of the stator design. In this case, the rotational movement of the inflow zone and the outflow zone is depicted by a linear movement of the matrix. The throughflow of the matrix into the individual segments shall be illustrated by the individual zones (6). A comparison with Figure 2 reveals that the rotor and the stator design may be described with the same substitution diagram.

Figure 5 depicts an exemplary design with a number of partial devices (11). This example shows the partial devices as separated. However, they can also be arranged in a common housing. The partial devices may exhibit switching elements (12), for example flaps or valves, and may be loaded with various gas streams (13), (14) in temporal alternation. Thus, various gas streams can flow through the matrix into the partial devices in temporal alternation. Figure 5 is an example of a design with three partial devices and two different gas streams. The inventive configurations can also include a plurality of partial devices and additional gas streams. Similarly, the various gas streams can also flow in from different sides.

Figure 6 is a substitution diagram of a design with separated partial devices. This design also shows the partial devices by means of various zones (6) in the substitution diagram. In the substitution diagram, the temporally alternating throughflow of the matrix into the individual partial devices is symbolized by means of a linear movement of the matrix through the individual zones (6) of the substitution diagram. A comparison with Figure 2 and Figure 4 reveals that this design can also be described with this substitution diagram.

In addition, additional designs, which can also be depicted with such a substitution diagram, are also conceivable.

Therefore, the steps of the method for exhaust gas purification in accordance with the invention shall be explained below with reference to such substitution diagrams.

Figure 7 depicts one variant of the method for exhaust gas purification with substream regeneration, in which air is used as the regenerating medium. In the case of trucks, the weak air stream that is required for regeneration may be taken, if desired, from the existing compressed air system, so that there is no need for an additional blower. The exhaust gas (15), coming from the engine, is cleaned in the matrix (16) in the largest zone of the configuration. In this design, the matrix can be made of particulate-filtering material for removing the soot particles from the exhaust air; or the matrix may contain such material. In this case, the particulate settles out of the exhaust air onto the particulate-filtering material. In many load conditions of the engine, the temperature of the exhaust gas is so low that no oxidation or only a slow oxidation of the soot particles occurs in this zone. The cleaned exhaust gas (29) leaves the device. Owing to the continuous or cyclical transport of the matrix between the individual zones (said transport is shown by the horizontal arrow in the diagram), the particulate- and nitrogen oxide-laden zones of the matrix pass into the regenerating segment (17), where the matrix is regenerated. The air (19), which is used for regeneration, flows first through the matrix in the heat exchange segment (18). In so doing, the air is heated by the hot matrix. If necessary, after the regenerating air has passed through the heat exchange segment, it can be additionally heated by means of a heater (20). At this stage, the regenerating air, which has been preheated in this way to the oxidation temperature, flows through the regenerating segment (17). At the same time the soot particles, which were deposited on the matrix, are oxidized into carbon dioxide by the hot regenerating air. In addition, the matrix, located in the regenerating segment, is heated by the reaction heat that is released. The exhaust gas from the regenerating segment can be fed with the cleaned engine exhaust gas to the muffler. Owing to the continuous or cyclic transport of the matrix between the individual zones (said transport being shown by the horizontal arrow in the diagram), that part of the matrix that is heated in the regenerating segment passes then into the heat exchange segment (18). In said heat exchange segment, at least one fraction of the heat of the matrix is absorbed by the incoming regenerating air (19); as a result, the regenerating air (19) in turn is heated.

The heater (20) may be designed as an electric heater or as a burner. The heater may be used, as a start heater, to start from the cold state. Since the amount of regenerating air can be controlled, the oxidation in turn can be controlled, so that the resultant temperature of the matrix can be limited.

In an especially advantageous design, the matrix (16) is equipped additionally with a storage catalyst in at least certain places. In this case, the exhaust gas (15), coming from the engine, is also cleaned of nitrogen oxides in the matrix in the largest zone of the configuration. In so doing, the nitrogen oxides attach themselves to the storage catalyst and are chemically bonded to said catalyst. In this case, the chemical reaction of the nitrogen oxides, bonded to the storage catalyst, also takes place in the regenerating segment. At the same time, the storage catalyst is regenerated. The chemical reactions in these steps are disclosed with respect to the typical storage catalysts of the prior art, so that there is no need to enter into a description of these reactions. In order to regenerate the storage catalyst, it may be especially advantageous to control the amount of regenerating air in such a manner that the oxygen of the regenerating air is at least largely consumed; and at least a small amount of carbon monoxide is formed. Due to this carbon monoxide, an especially good regeneration of the storage catalyst takes place. At the same time, the carbon monoxide on the storage catalyst is converted into environmentally safe substances.

At the point of the regeneration of the storage catalyst, hydrocarbons - for example, from the fuel - can also be used for regenerating the storage catalyst. In this case, a small amount of the hydrocarbons (21) may be added to the regenerating air before entering into the regenerating segment.

Another advantageous embodiment is shown in Figure 8. In this figure, there is a catalyst (22) in front of the inlet into the regenerating segment. The hydrocarbons (21), which were added, are oxidized on this catalyst. Thus, the temperature of the regenerating air entering into the regenerating segment, in addition can be heated.

In another advantageous embodiment, the matrix (16) can be equipped - preferably coated - with a catalyst, for example, a precious metal catalyst, in at least certain places. This catalyst promotes, first of all, the oxidation of the soot particles, so that this oxidation can take place at lower temperatures. Secondly, the metered hydrocarbons (21) can also be oxidized on this catalyst. Thus, the temperature of the matrix (16) can be raised even higher, so that an improved oxidation of the deposited soot particles takes place. Of course, this configuration of a catalyst on or in the matrix can also be applied in an advantageous manner to the designs listed below.

Figure 9 depicts an additional embodiment of the method. In place of air, a weak substream (23) from the cleaned exhaust gas of the engine is used for regeneration. This method has the following advantages. First of all, the exhaust gas is already warmer. Thus, altogether higher temperatures can be achieved during regeneration. Secondly, the exhaust gas exhibits a lower concentration of oxygen. This feature is especially advantageous if a storage catalyst is used at the same time. Then, optimal regeneration of the storage catalyst can take place with the oxygen-leaner gas in the regenerating segment. With this configuration, there is the minor drawback that the exhaust gas stream has to be conveyed with a blower (24).

Figure 10 depicts an additional embodiment with substream regeneration, in which the regenerating air can be preheated in a heat exchanger (25), which is located additionally upstream. This heat exchanger can be designed, for example, as a plate-like heat exchanger or as a heat exchanger with ribs. The use of a counter-current heat exchanger is advantageous. Owing to the preheating of the regenerating air in the upstream heat exchanger, it is possible to achieve altogether higher temperatures during regeneration.

Figure 11 depicts a simple design of a device that makes do without a heat exchange segment. Since in this case, the regenerating gas exhibits just a lower temperature, the regenerating gas has to be heated presumably with an additional heater (26). This heat input can also be achieved by burning additional fuel. If necessary, this combustion can take place on an upstream catalyst. In this design a substream (27) of the exhaust gas, coming from the engine, can be used as the regenerating gas. Since this exhaust gas exhibits a somewhat higher pressure level owing to the pressure loss of the downstream matrix, no blower is necessary. In this case the amount of regenerating gas can be controlled in a simple way by means of a flap (28).

Figure 12 and Figure 13 depict a design with substream regeneration. In this case, the uncleaned engine exhaust gas is used for regeneration. The design in Figure 13 matches the design in Figure 12, if in Figure 12 the rotor's direction of rotation is reversed. In these designs, the regeneration takes place by means of uncleaned engine exhaust gas. In order to start from the cold state, a start heater can be provided. In the design in Figure 12, the heat of the heated matrix is not used in its entirety. In the design in Figure 13, the bulk of the heat of the hot regenerating gas is dragged into the exhaust gas.

This heat may be exploited in a number of different ways, as Figure 14 and Figure 15 show by way of example.

In the images in Figure 11 to Figure 14, the amount of the substream can be controlled by means of a flap. If the mass flow in the regenerating gas segment is selected lower than in the exhaust gas cleaning segment, the pressure of the exhaust gas may be sufficient to push the substream of the regenerating gas through the regenerating segment and the heat exchanger segment (especially since in the arrangement in Figure 14 and Figure 15, the heat exchanger segment is already cleaned). However, the pressure of the exhaust gas upstream of the particulate filter depends on the anticipated loading of the particulate filter and may change during operation. Therefore, a blower may become necessary in order to convey the regenerating gas.

Figure 14 depicts the design in Figure 13, which, however, has been expanded to include an additional heat exchanger. Therefore, heat, generated in the regeneration process, can be transferred to the incoming regenerating gas.

As an alternative, as shown in Figure 15, this heat can be transferred in another regenerating segment to that section of the rotor matrix that enters into the regenerating segment at the next time step. This variant has the drawback that three passages through the filter material must occur, a feature that leads to a higher pressure loss on the regenerating gas side.

Other circuits with another configuration of the heat exchange segments and the fluid connections are also possible, in order to further improve the use of the heat. For example, it is possible to conceive of an additional advantageous circuit, wherein, however, the uncleaned exhaust gas has to be returned from the rear side. However, it must also be considered with these additional circuits that, on the one hand, the need for additional equipment increases dramatically; and, secondly the number of deflections of the fluid, as well as, if necessary, the number of passages through the filtering matrix also increases, thus raising the pressure loss of the regenerating gas.

Another embodiment of the method is depicted in Figure 16. In this design, a substream from the exhaust gas, coming from the engine, is also used as the regenerating gas. The amount of this regenerating gas can be controlled by means of a flap. The regenerating gas flows through a first heat exchanger segment. At the same time, the regenerating gas is preheated by the hot matrix. If necessary, the regenerating gas can be subsequently heated to a higher temperature by a heater. Thereafter the regenerating gas flows into the regenerating segment, where the regeneration takes place. Owing to the oxidation reactions during regeneration, both the regenerating gas and the matrix are heated. Then the regenerating gas, which was heated by the reaction, flows through a second heat exchanger segment, where the regenerating gas cools down and dissipates heat to the matrix. Therefore, the matrix is preheated. Then the matrix, which is heated in this manner, moves into the regenerating segment. Then the matrix, which is heated to a higher temperature by the oxidation reactions in the regenerating segment, passes into the first heat exchanger segment, where the heat of the matrix is absorbed by the inflowing regenerating air. In this design of the method, the heat exchange is especially extensive.

The cited embodiments represent mere examples of a few possibilities. Other embodiments and, in particular, of course, combinations of the presented embodiments are possible.

Method for Purifying Exhaust Gases

List of Reference Numerals for Figure 1 to 6:

1	rotor
2	matrix of the rotor segment
3	inflow zone
4	outflow zone
5	segments of the rotor
6	zones (in the substitution diagram)
7	stationary matrix of the stator design
8	rotating inflow zone (inflow zone) of the stator design
9	rotating outflow zone of the stator design
10	segments of the inflow and outflow zone
11	partial devices
12	switching elements (in the design with the partial devices)
13	gas stream 1
14	gas stream 2

Claims

1. Method for purifying exhaust gases, characterized by the following features:
   - that the particulate air impurities and/or nitrogen oxides are deposited on a filtering medium
   - simultaneously, the filtering medium is regenerated by reactive conversion of the deposited substances
   - an air stream or gas steam, which is weaker than the exhaust gas stream, is used in order to regenerate the filtering medium.
   - In addition, the regeneration of a part of the filtering medium takes place simultaneously, whereas in other areas of the filtering medium, the cleaning of the exhaust gas stream takes place.

2. Method, as claimed in claim 1, characterized in that the heat, which is generated during the reaction, is absorbed at least partially by a heat-storing medium.

3. Method, as claimed in claim 1, characterized in that the heat, which is stored in the heat-storing mass, is used at least partially to preheat the regenerating gas.

4. Method, as claimed in claim 1, characterized in that at least a part of the filtering medium in the areas to be cleaned and at least a part of the filtering medium in the regenerating areas are exchanged continuously or cyclically.

5. Method, as claimed in claim 1, characterized in that at least a part of the filtering medium is exchanged continuously or cyclically between cleaning areas, regenerating areas, and heat exchanging areas.

6. Method, as claimed in claim 1, characterized in that the filtering medium is regenerated by oxidation of the particulate air impurities, which have settled out on the filtering medium.

7. Method, as claimed in claim 1, characterized in that the filtering medium is provided, in at least certain places, with a substance that absorbs nitrogen oxides by means of attachment and chemical bonding.

8. Method, as claimed in claim 7, characterized in that the nitrogen oxide-bonding substance can be regenerated by means of reaction.

9. Method, as claimed in claim 1, characterized in that carbon monoxide, which is generated during the generation of particles, is used for regenerating the nitrogen oxide-bonding substance.

10. Method, as claimed in claim 1, characterized in that, by controlling the amount of regenerating air, at least a partially incomplete oxidation is induced with simultaneous formation of carbon monoxide.

11. Method, as claimed in claim 1, characterized in that the amount of regenerating air is controlled, in such a manner, that in the regenerating area temperatures exceeding 450 °C, preferably temperatures exceeding 550 °C are reached.

12. Method, as claimed in claim 1, characterized in that the filtering medium is provided at least in certain places, with a catalyst that promotes the oxidation of particles.

13. Method, as claimed in claim 1, characterized in that the regenerating gas is preheated initially in a heat-exchanging zone; thereafter undergoes a reaction in a regenerating zone.

14. Method, as claimed in claim 1, characterized in that the regenerating gas is preheated initially in a heat-exchanging zone; thereafter undergoes a reaction in a regenerating zone; and then its heat is dissipated at least to some extent to an additional heat-exchanging zone.

15. Method, as claimed in claim 1, characterized in that a weak air stream is used as the regenerating gas.

16. Method, as claimed in claim 1, characterized in that a weak substream of the exhaust gas is used as the regenerating gas.

17. Device for carrying out the method, as claimed in claim 1, characterized in that the device exhibits different functional areas.

18. Device for carrying out the method, as claimed in claim 1, characterized in that the device exhibits different functional areas; and a filtering matrix passes continuously or cyclically through these different functional areas.

19. Device, as claimed in claim 18, characterized in that the functional areas include at least one cleaning zone, in which the exhaust gas is cleaned.

20. Device, as claimed in claim 18, characterized in that the functional areas include at least one regenerating zone, in which the filtering matrix is regenerated

21. Device, as claimed in claim 18, characterized in that the functional areas include at least one heat-exchanging zone, in which the heat is transferred between the matrix and the regenerating gas.

22. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises a rotating element, which exhibits different functional areas.

23. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises at least one rotating element, which exhibits different functional areas; and a filtering matrix passes continuously or cyclically through these different functional areas

24. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises a rotating matrix, which passes continuously or cyclically through different functional areas for cleaning and regeneration.

25. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises a rotating matrix, which passes continuously or cyclically through different functional areas for cleaning, regeneration and heat exchange.

26. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises at least one rotating element, which distributes various gas streams to different functional areas.

27. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises at least one rotating element, which distributes various gas streams to different functional areas, and, thus, a filtering matrix undergoes continuously or cyclically steps comprising cleaning and regeneration.

28. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises at least one rotating element, which distributes various gas streams to different functional areas, and, thus,

a filtering matrix undergoes continuously or cyclical steps comprising cleaning, regeneration, and heat exchange.

29. Device for carrying out the method, as claimed in claim 1, characterized in that the device comprises partial devices, which serve different functions; and their functions are exchanged cyclically.

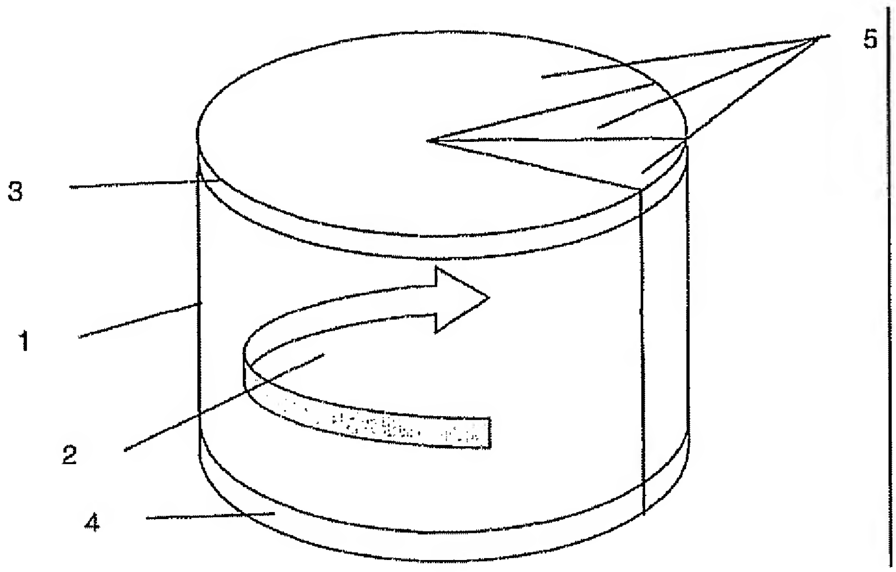

Figure 1: Exemplary design of a rotor with segmental inflow and rotational direction

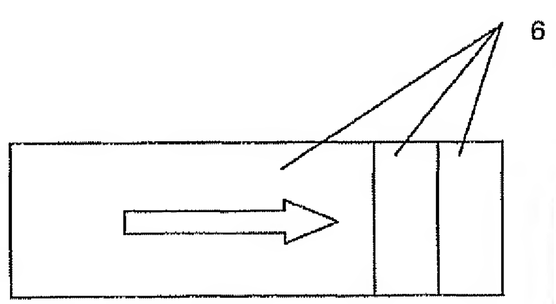

Figure 2: Substitution diagram of the rotor

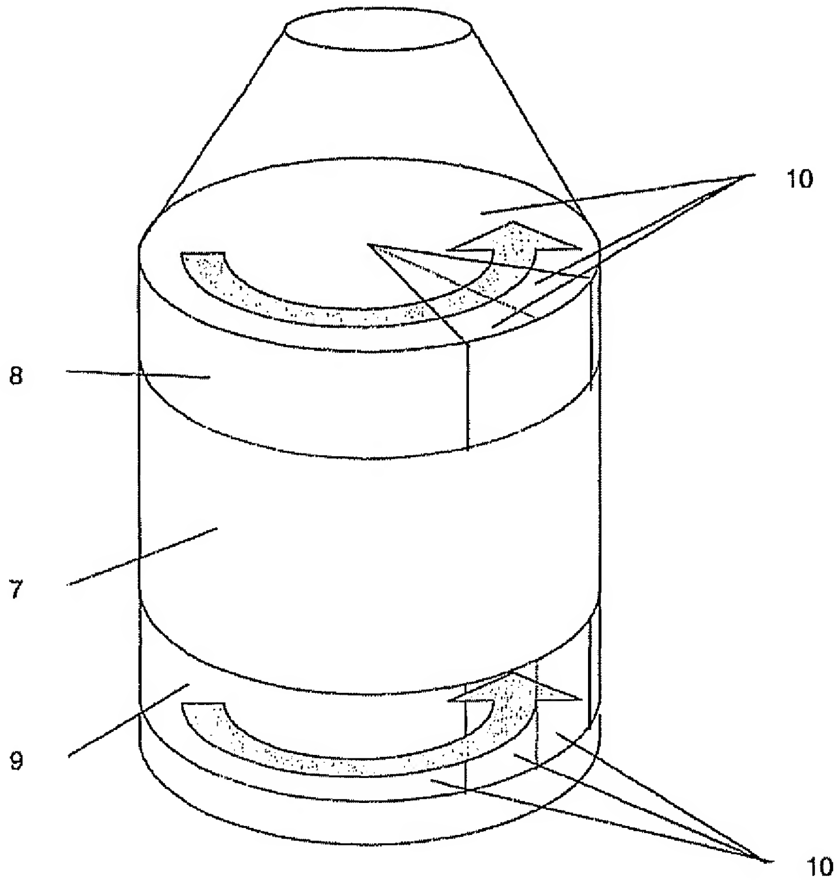

Figure 3: Exemplary design of a stator design with segmental inflow and rotational direction

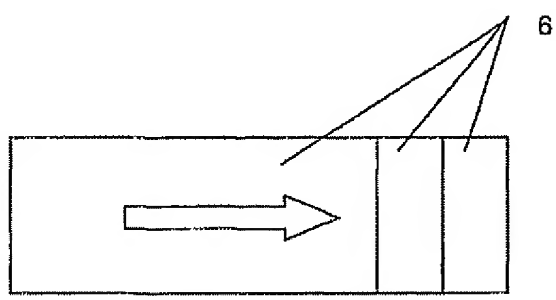

Figure 4: Substitution diagram of the stator design

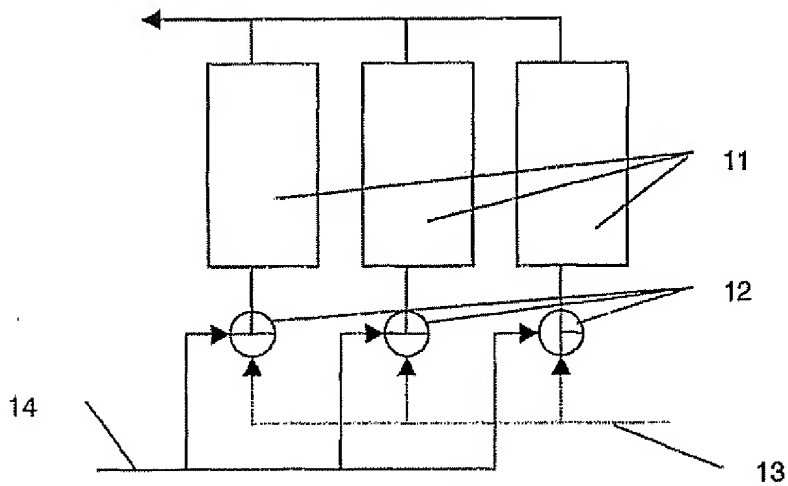

Figure 5: Exemplary design with a number of partial devices

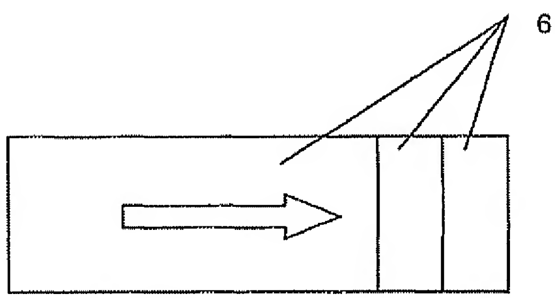

Figure 6: Substitution diagram of the design with a number of partial devices

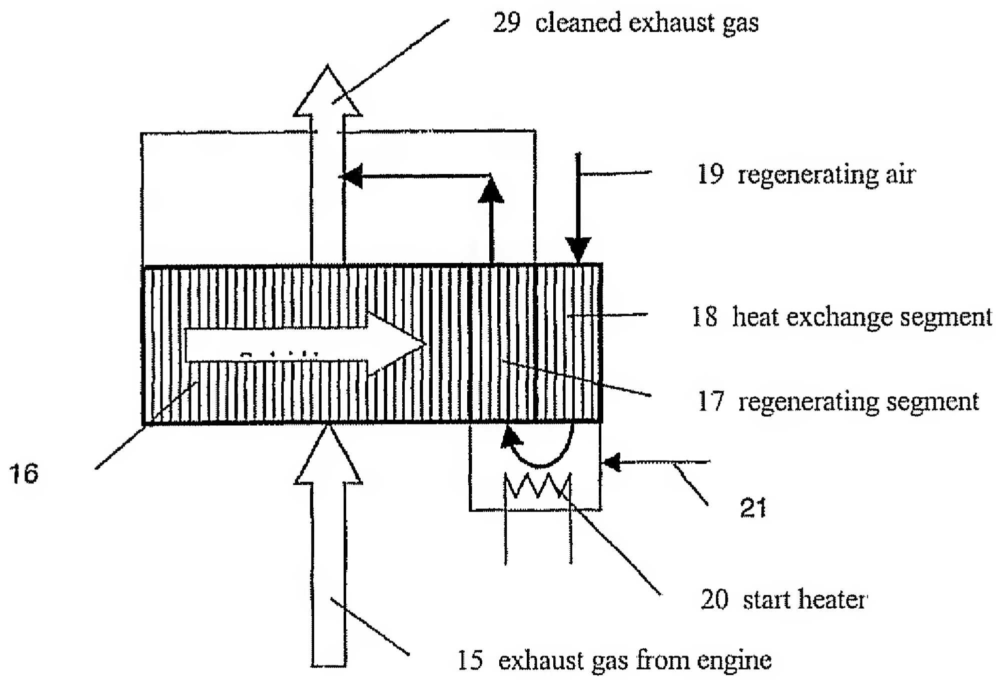

Figure 7: Diesel particulate filter rotor with substream regeneration
Regenerating medium air, configuration with heat exchange segment

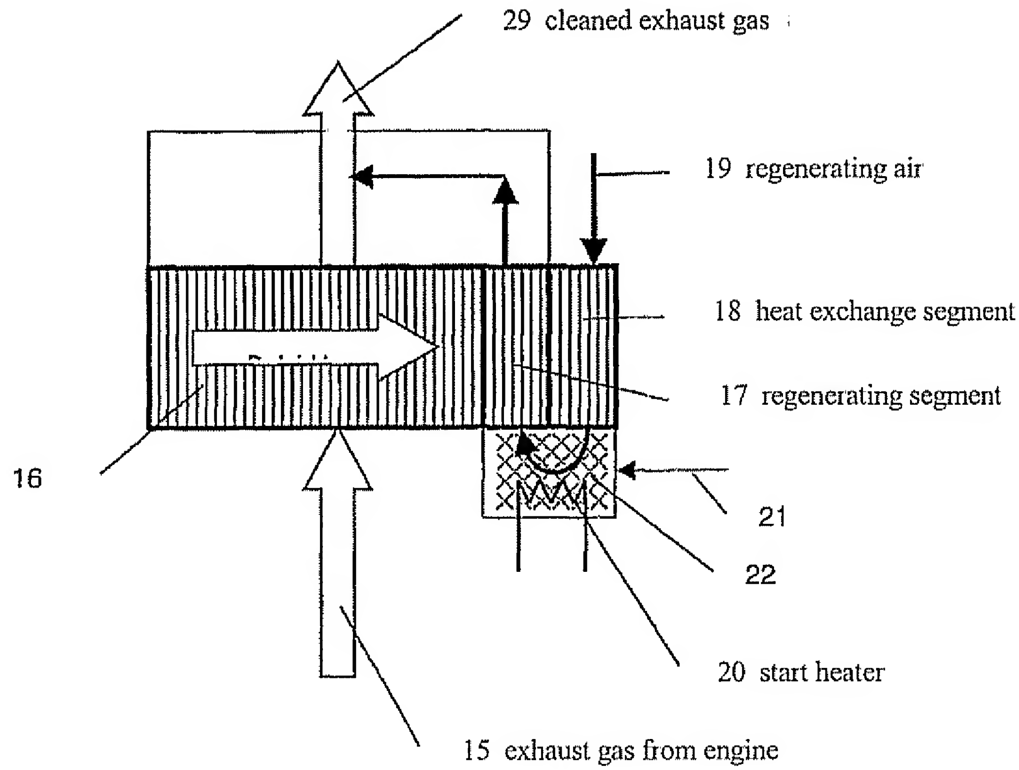

Figure 8: Diesel particulate filter rotor with substream regeneration
Regenerating medium air, configuration with heat exchange segment and the addition of hydrocarbons, configuration with catalyst located upstream

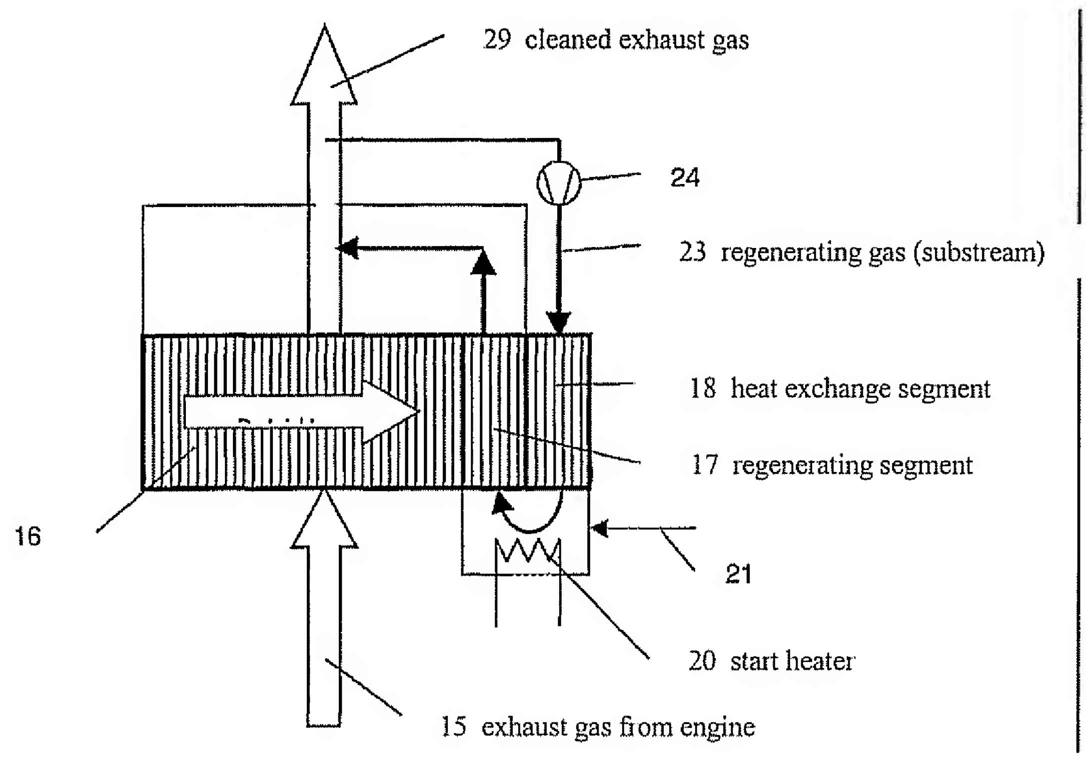

Figure 9: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with heat exchange segment

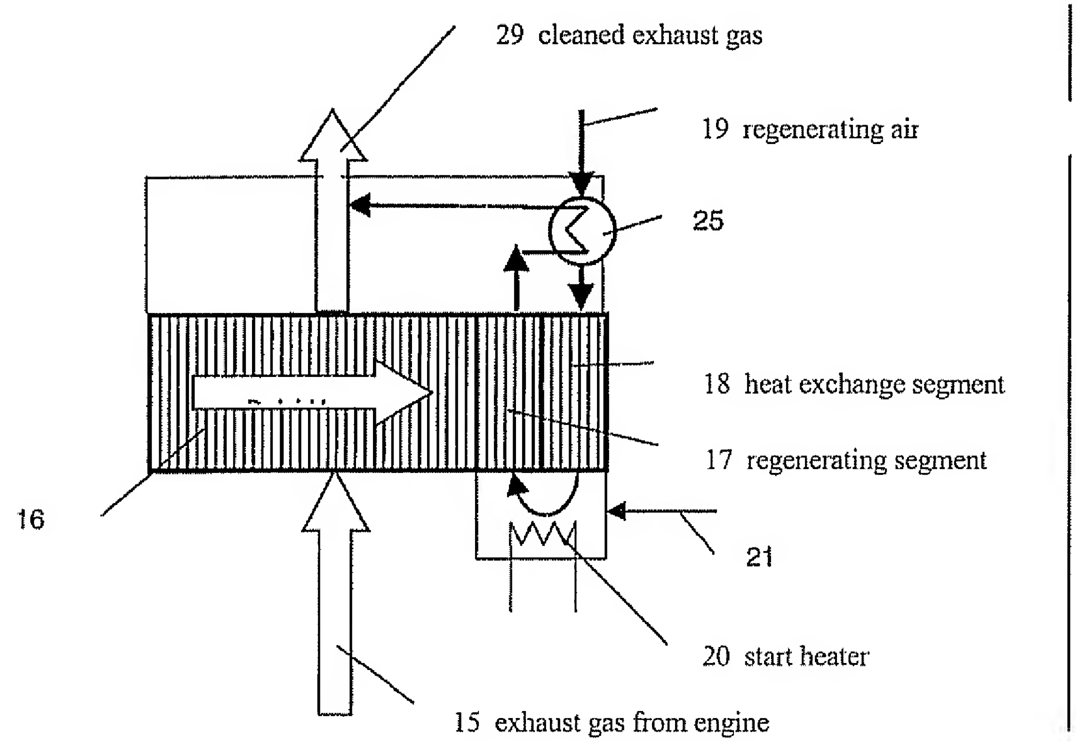

Figure 10: Diesel particulate filter rotor with substream regeneration
Regenerating medium air, configuration with heat exchange segment with additional heat exchanger

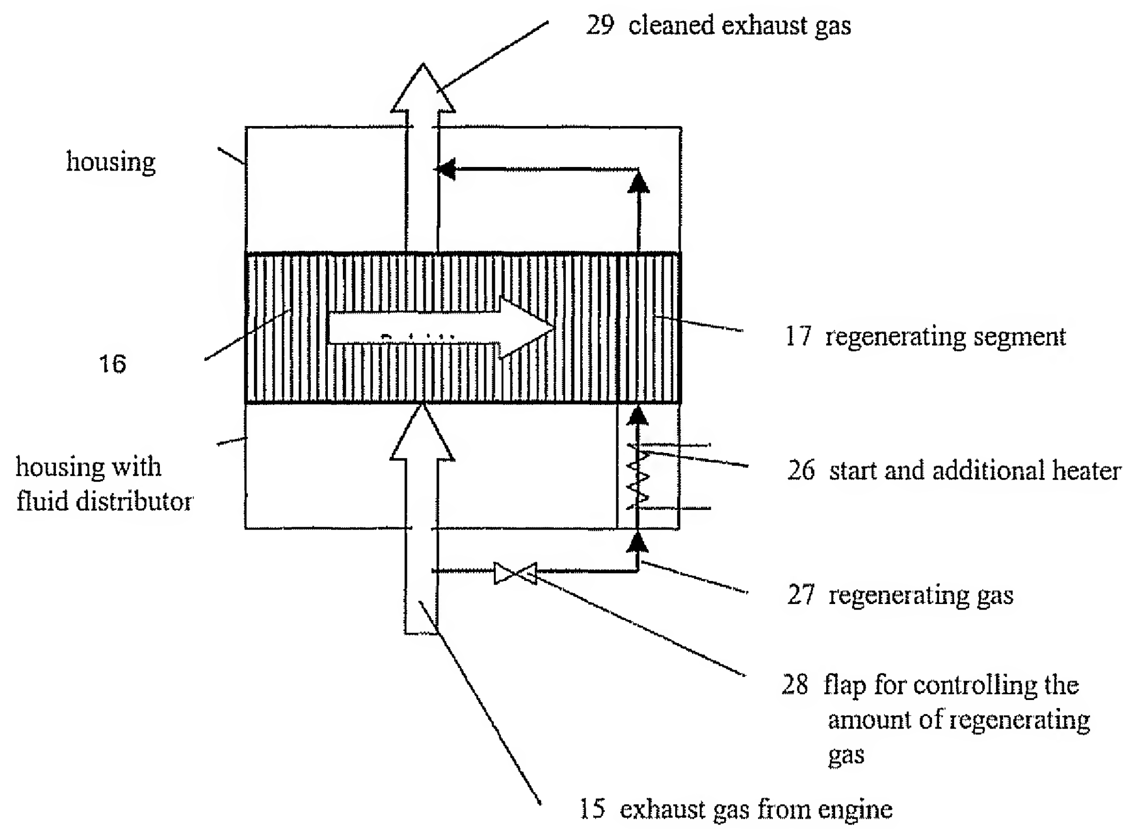

Figure 11: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration without heat exchange

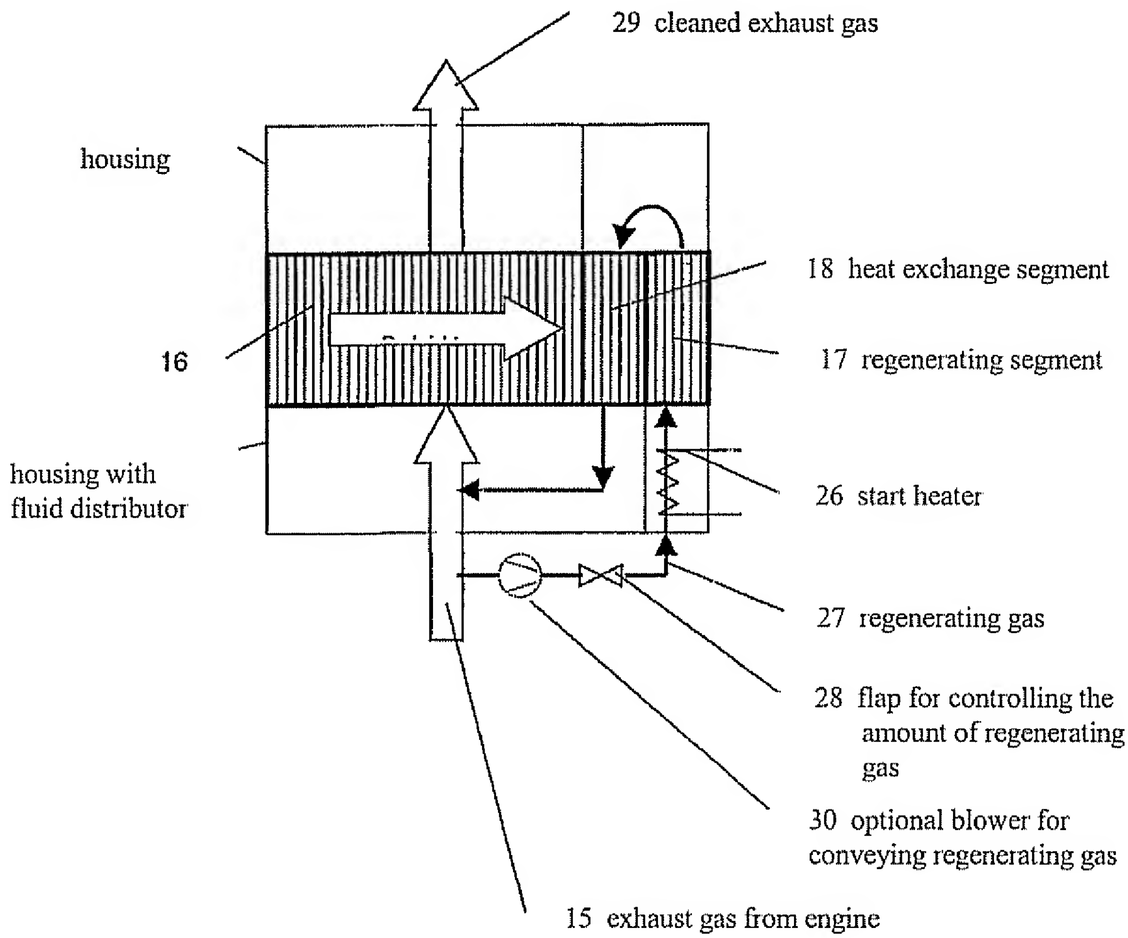

Figure 12: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with heat exchange segment

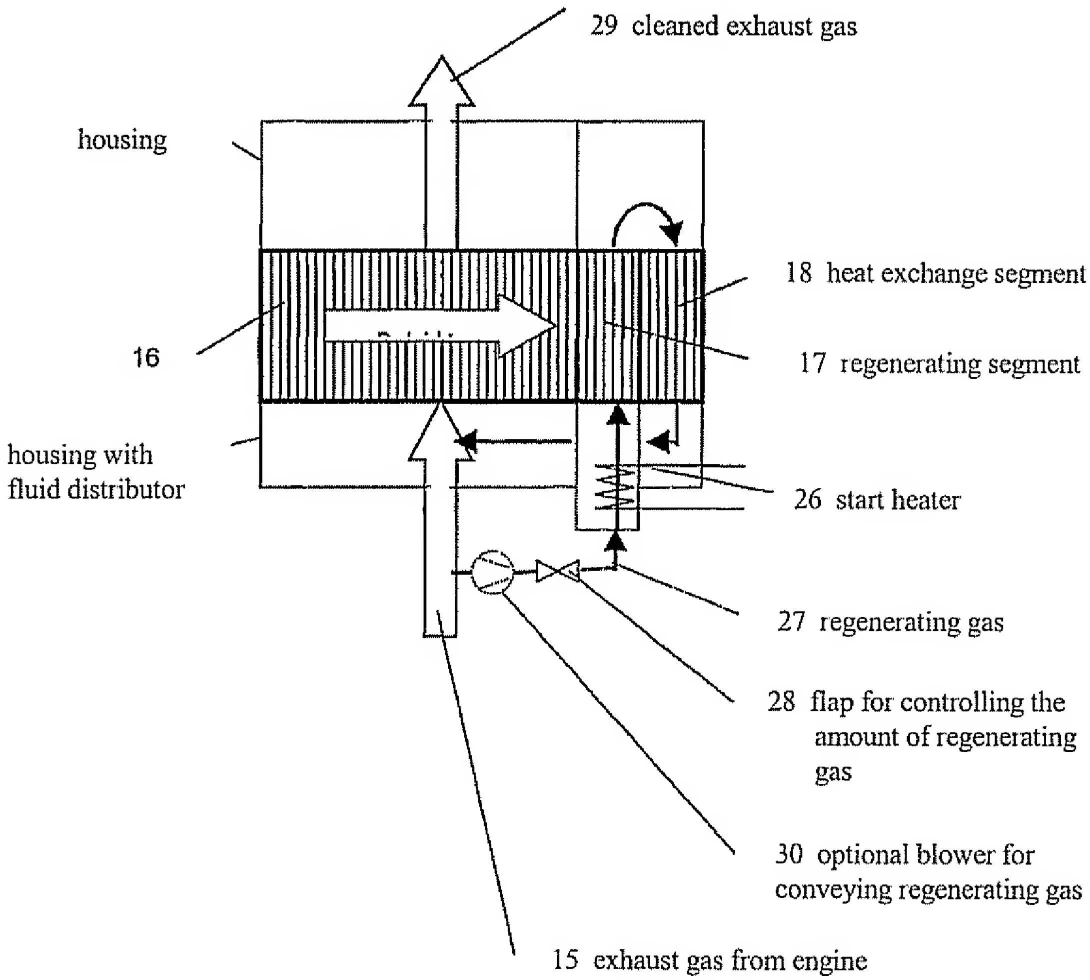

Figure 13: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with heat exchange segment

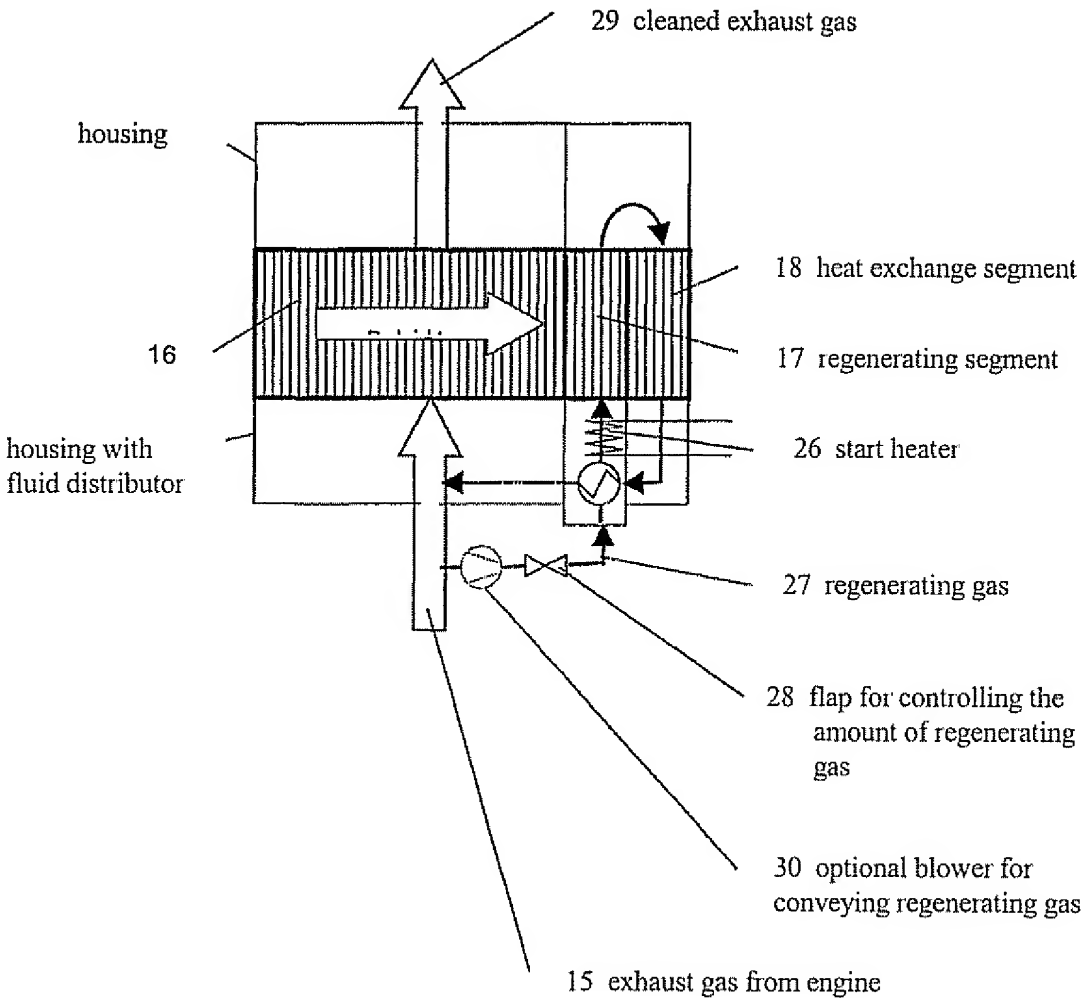

Figure 14: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with heat exchange segment and additional heat exchanger

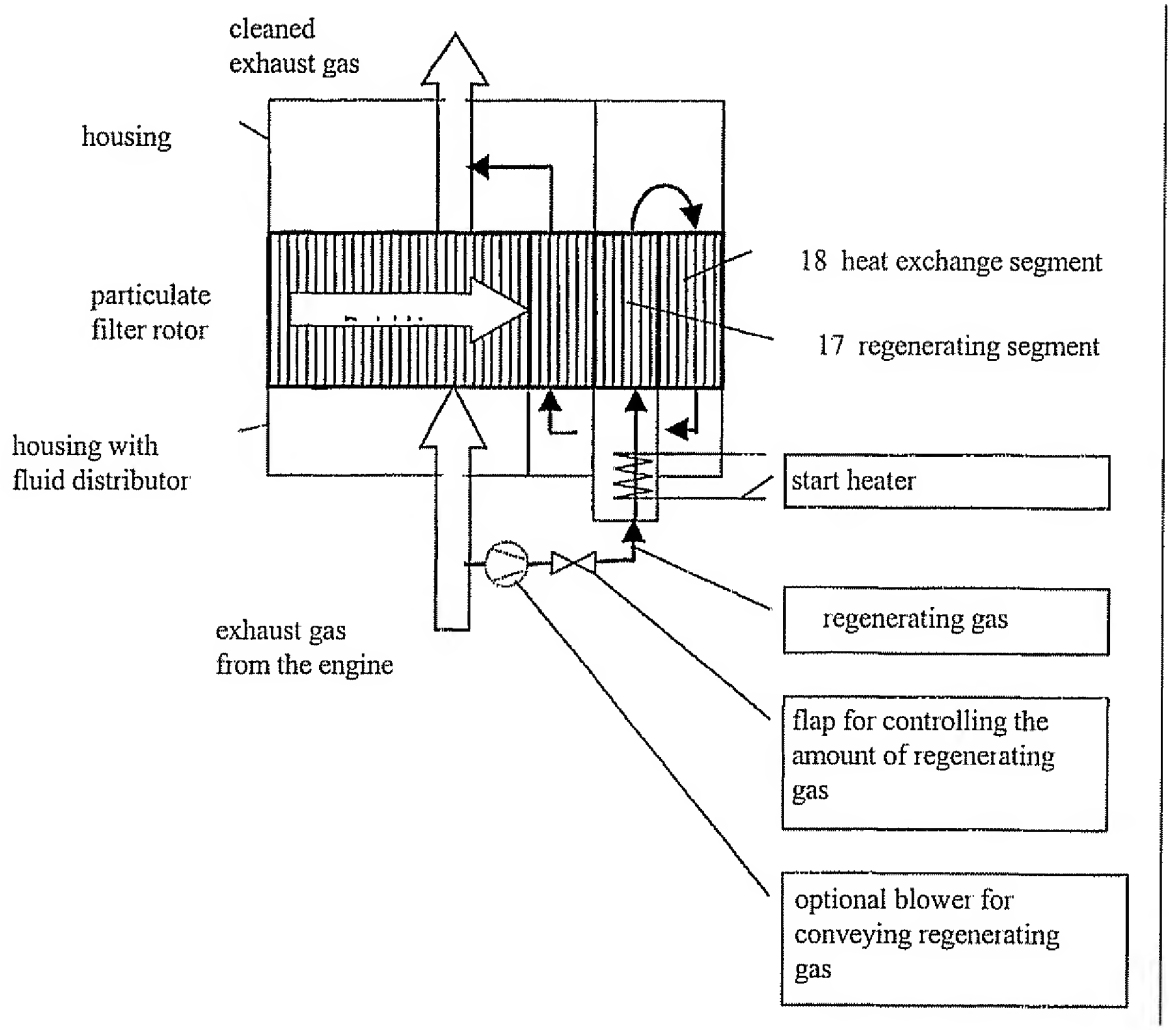

Figure 15: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with two heat exchange segments

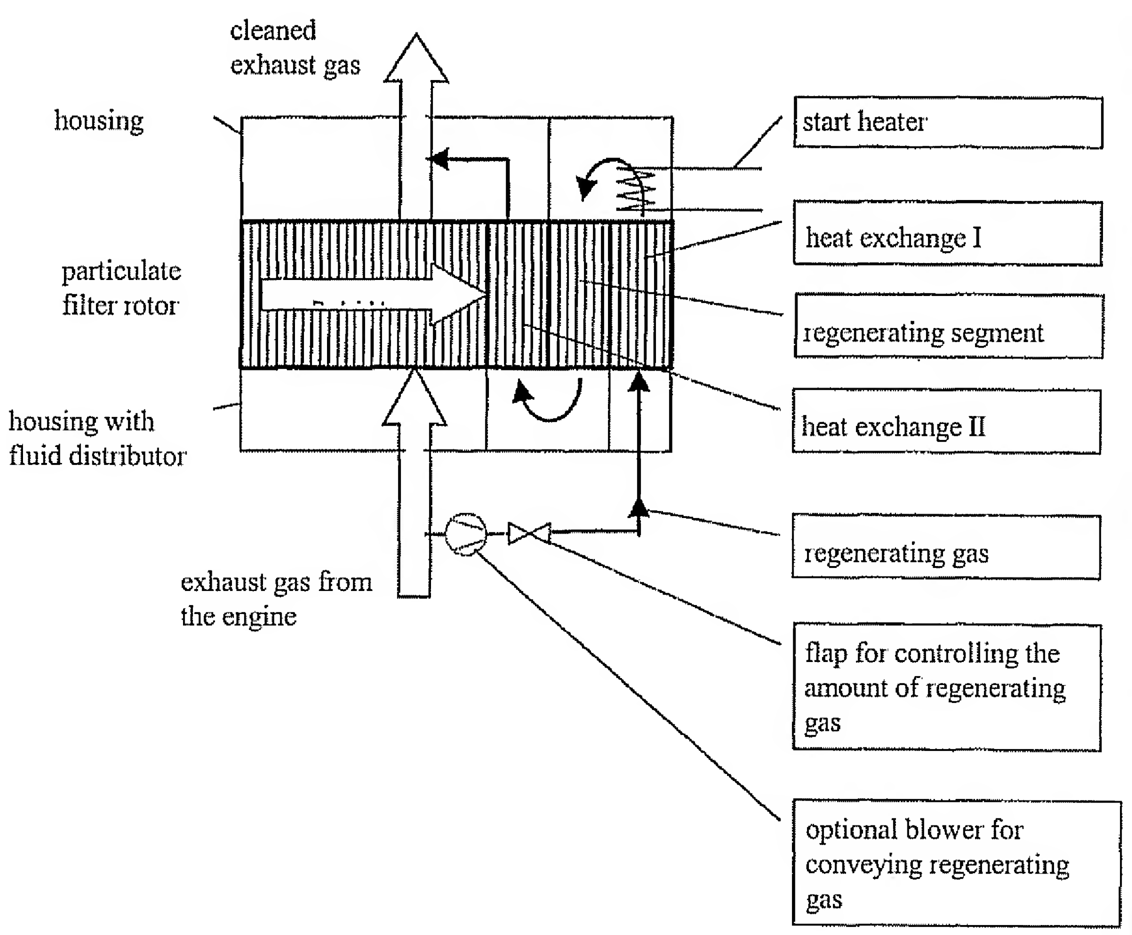

Figure 16: Diesel particulate filter rotor with substream regeneration
Regenerating medium exhaust gas (substream), configuration with two heat exchange segments